GROWTH AND DEVELOPMENT OF

CHRYSANTHEMUM CARINATUM SCHOUSB. (ASTERACEAE)

by

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Introduction

Annual chrysanthemum or rainbow daisy (Chrysanthemum carinatum Schousb.), native to the Atlas Mountains of Morocco, was brought into cultivation in 1796. Leaves are pinnatifid into linear lobes and borne on long, stiff stems forming an upright, bushy plant reaching to 60 cm in height. The flowers are approximatly 6.4 cm in width with yellow bands on white rays which encircle the purple disk (Booth, 1957; Gould, 1985; Scott, 1950). There are named varieties, mixes, and doubles available (Rockwell, 1955). 'Dunnettii Choice Mix' (Stokes Seeds, Inc. Buffalo, NY 14240) consists of double flowers such as yellow, pink, white, and rose as well as several bicolored combinations. A single-flowered variety called Rainbow Mix (W. Atlee Burpee Co., Warminster, PA 18974) has white, yellow, rose, and orange bicolored flowers with orange or yellow bands. Another single-flowered variety, Single Annual Mix (Stokes Seeds Inc., Buffalo, NY 14240), includes yellow, pink, purple, and rust bicolored flowers.

Consumer demand in the United States for uncommon and interesting potted plants is increasing. Growers must produce new crops to meet the demand (Armitage, 1986). The unusual characteristics of rainbow daisy give it potential to help fill the demand. The multicolored flowers and unique foliage differ from many traditional crops.

Greenhouse production of rainbow daisy can be as a winter-crop grown at cooler greenhouse night temperatures reducing production overhead for the grower. Obstacles to successful crop production include germination, branching, photoperiodic response, and excessive height. Therefore, the objectives of this research were to study growth and development of rainbow daisy and develop production guidelines.

Literature Review

New potted plants are more in demand than at any other time in the United States. Armitage (1986) has proposed a 3-phase scheme for evaluating new flowering crops (Fig. 1). Species with insurmountable inadequacies in any phase are deemed unacceptable. The scheme demonstrates where problems arise with species having potential.

C. carinatum has been classified as C. atrococcineum, C. bicolor, C. burridgeanum, C. dunnettii, C. matricaroides (Booth, 1957), and C. tricolor (Rockwell and Grayson, 1955; Booth, 1957). C. coronarium also is commonly known as annual chrysanthemum. It has yellow single (Post, 1950) or double flowers (Scott, 1950).

Many varieties resulted from crosses of C. carinatum with other species (Booth, 1957). Singles and doubles are available in over 20 tricolored varieties in many colors for outdoor display plantings. Seed variability prohibits 100% double varieties resulting in singles and semi-doubles to be included in the mixes (Gould, 1985).

Rainbow daisy has been grown primarily for cut flowers (Booth, 1957). Chlormequat, (2-Chloro-N,N,N-trimethylethanamonium chloride) and maleic hydrazide (1,2-dihydro-3,6-pyridazinedione) increased branching and subsequently, cut flower yield (Rathore et al., 1979).

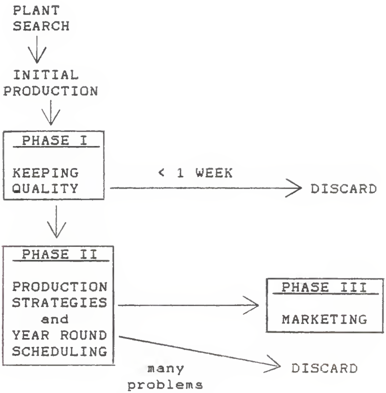

Figure 1. Overal plan for evaluation of new potted crops (Armitage, 1986).

Flowers can be cultivated outdoors in summer and in greenhouses in spring (Post. 1950). In Germany, successful cut flower production of annual chrysanthemum has been achieved in unheated, plastic greenhouses (Loeser, 1982).

The optimum temperature for growth and flowering of this crop is 13°C nights (Post, 1950). Growing crops in greenhouses at this relatively low temperature reduces production costs. Savings are maximized in winter months (Hurd, 1981). Rainbow daisy flowers sooner under longdays (LD) than shortdays (SD) (Post, 1950). Seedlings grown under SD for 8 weeks, then exposed to LD flower 5 months after sowing (Booth, 1957).

Photoperiod responses of plant growth and flowering was first studied by Garner and Allard in 1920. Induction of bolting and flowering in tobacco and other species was attributed to daylength. Photoperiod effects can be modified by temperature, mineral nutrients, light wavelength and intensity, and humidity (Salisbury, 1982).

During SD, rainbow daisy seedlings developed vegetative growth in a tight rosette of foliage. Extensive internode elongation begins with the onset of flower development which occurs sooner under LD than SD (Albrecht, unpublished data). Plants which flower sooner under LD than SD are known as quantitative (facultative) longday plants (LDP) (Fig. 2) (Salisbury, 1982).

Both *Spinacea oleracea* (spinach) and *Silene armeria*, which have been extensivly studied, respond as LD rosette plants as does rainbow daisy (van den Ende and Zeevaart, 1971; Zeevaart, 1971). In spinach, the initial morphological responses to LD was upright orientation of foliage and petiole extension. The increased growth response under LD was attributed to two factors: 1) an increased metabolism rate of endogenous gibberellins, and 2) an increased sensitivity of tissue to gibberellins (Zeevaart, 1971). Further studies revealed LD photoperiod activated specific enzymes. These enzymes metabolized specific forms of endogenous gibberellic acid (GA), causing a change of the types of GA in the plant. In spinach, enzymatic oxidation of GA_{53} and GA_{19} was high under LD conditions and was low under SD conditions or darkness, while enzymatic oxidation of GA_{44} remains high regardless of darkness (Gilmour and Zeevaart, 1986). Analysis of leaf and stem tissue of *Agrostemma githago* indicated photoperiod controls turnover rate of various endogenous GA's (Jones and Zeevaart, 1980).

In the LD rosette plant *Silene armeria*, LD photoperiods induced increased GA metabolism as demonstrated by the conversion of $^3H\text{-}GA_5$ to two unidentified acidic compounds. The conversion rate declined after SD resumed. Stem elongation seemed to

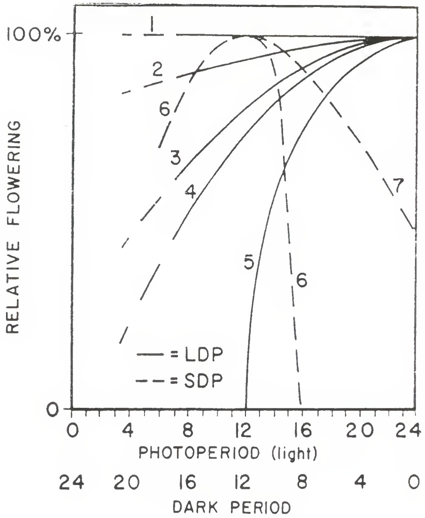

Fig. 2. Schematic representation of photoperiod responses. 1. A truly day-neutral plant. 2. Slight promotion by LD. 3 and 4. Quantitative LD plants. 5. Qualitative LD plant. 6. Qualitative SD plant. 7. Quantitative SD plant. (Salisbury, 1982).

parallel this metabolic rate (van den Ende and Zeevaart, 1971).

The enzymatically controlled metabolism of GAs in spinach leaves under LD was:

$$GA_{12} \dashrightarrow GA_{53} \dashrightarrow GA_{44} \dashrightarrow GA_{20} \dashrightarrow GA_{29}.$$

Therefore, the concentration of GA_{20} under LD was higher than under SD (Gilmour and Zeevaart, 1986; Metzger and Zeevaart, 1979). LD conditions resulted in increased GA_{20} and GA_{29} concentrations (Metzger and Zeevaart, 1982). The high GA_{20} concentration under LD caused stem elongation which was photoperiodically controlled and GA induced (Metzger and Zeevaart, 1980).

High GA levels are necessary for flower bud initiation (FBI) (Baldev and Lang, 1965) and are involved with flower development in numerous LDP's (Sladky, 1986). FBI has been experimentally separated from stem elongation in the rosette LDP <u>Silene armaria</u>. Flower primordia formed before stem elongation occured (Cleland and Zeevaart, 1970). In the LDP <u>Samolus parviflorus</u>, three LD photoinductive periods were necessary before FBI could begin, and required four more photoinductive periods for the process to be completed. Development of lateral branches occured during the fifth and sixth photoinductive periods (Baldev and Lang, 1965).

Rainbow daisy reached heights from 60 to 90 cm by

anthesis (Rockwell and Grayson, 1955). Height and width are important quality factors for flowering potted plants. Quality plants are less than three times the height of the pot, including the pot, and have a width less than three times the width of the pot (Staby et al., 1976). For rainbow daisy to be a quality crop in 15-cm pots, a growth retardant must be applied to reduce internode elongation and maintain height at approximatly 30 cm.

Chemical growth retardants retard internode elongation by effectively inhibiting GA synthesis (Baldev and Lang, 1965) without seriously disrupting growth processes (Cathy, 1975). There are several methods of application including: foliar spray, media drench, bark dressing (Sachs and Hackett, 1972), aerosol fog, and direct injection into the cambial area (Cathey, 1975). Application timing is important and depends on the chemical, desired response, species, and growth stage (Sachs and Hackett, 1972). The degree of control is determined by the concentration of the chemical in the tissue. Dosage, formulation, and frequency of applications depend on the species, intended use, method of application, stage of development, and climatic conditions at the time of application (Sachs and Hackett, 1972).

Responses to growth retardants are species specific due to differences in absorption, transport, or metabolism

of the chemical (Sachs and Hackett, 1972). Other factors that determine the effectiveness of treatments include: cultivar, soil moisture, air temperature, watering and fertilization schedules, freedom from pests, use of surfactants, plant age and size, and method of application (Larson, 1985).

Young plants show a greater response to growth retardants because they absorb the chemical more readily, and the chemical is present at the onset of shoot growth. Greenhouse grown plants have thinner cuticles than outdoor grown plants allowing chemicals to be absorbed more easily. Higher humidity in a greenhouse causes the chemical to remain on the leaf longer before evaporating. Consequently, lower concentrations can be applied as foliar sprays (Sachs and Hackett, 1972).

Larson (1985) argues that growth retardants are less effective on young tissue because young leaves have thicker cuticles which form a barrier to foliar sprays. Growers prefer foliar sprays because chemicals can be applied to many small plants rapidly and with a minimum amount of diluent. Efficient applications give maximum control with minimum amounts of chemical and minimum delay in flowering (Cathey, 1975).

Ancymidol, [α -cyclopropyl-α-(4-methoxyphenyl)-5-pyrimidinemethanol] blocks the oxidation of GA-biosynthesis

intermediaries ent-kaur-16-ene, ent-kaur-16-en-19-ol, and ent-kaur-16-en-19-al (Coolbaugh et al., 1978). Low concentrations of ancymidol as a foliar spray effectively reduced internode elongation (Abdel-Rahman et al., 1981) without influencing floral pigments or leaf color. Some cultivars suffered delayed flowering while others flowered sooner (Cathey, 1975).

Excess ancymidol can stop growth completely and sometimes irreversibly, causing spongy parenchyma in the leaves to be disorganized (Cathey, 1975). Foliar applications of ancymidol need to be applied prior to flower bud development and remain on the foliage only 5 minutes to be completely effective (Cathey, 1975). Automatic watering systems do not influence the effectiveness.

Daminozide, [butanedioic acid mono(2,2-dimethylhydrazide)] was first studied in 1962. Dennis et al. (1965) researched the GA synthesis inhibition site of daminozide and other carbamate esters. These compounds inhibited cyclization of transgeranylgeranyl pyrophosphate, inhibited (-)-kaurene(IIa) formation and subsequent GA formation, thus stimulating formation of transgeranylgeraniol.

Daminozide was effective on 44 of 88 species tested (Cathey, 1975) and induced a wide range of plant responses

including: reduction of internode elongation (Abdel-Rhaman et al., 1981), deeper greening of immature leaves, formation of an additional layer of palisade parenchyma, and an inability of leaves to fully expand. Floral pigment changes have occurred in some varieties of petunias (pink and purple turn to gray) and some white chrysanthemums (they turn cream-colored) (Cathey,1975). Daminozide may inhibit respiration in mitochondria of leaf cells (See and Foy, 1983); increase heat, drought, and pollution tolerance; and promote flower bud formation (Larson, 1985). Relatively high concentrations of daminozide reduced stem elongation without causing foliar injury (Sachs and Hackett, 1972). Excessive applications of daminozide induced little or no increased effectiveness apparently due to a lack of absorption (Cathey, 1975).

It has been reported that foliar sprays of daminozide must remain in contact with the leaf surface for at least 24 hours (Cathey, 1975) to be fully effective. Young tissue more readily absorbs the chemical but translocation occurs mostly in the older tissue (Larson, 1985) in both the xylem and the phloem (Menhenett, 1984). Daminozide must be applied at or before FBI. Later applications will cause flower distortion (Cathey, 1975).

Paclobutrazol, { β -[(4-chlorophenyl)methyl]-α-(1,1-dimethylethyl)-1H-1,2,4-triazole-1-ethanol} inhibits GA

synthesis (Goulston, 1985; Hedden and Graebe, 1985) at the same enzymatic sites as ancymidol (Hedden and Graebe, 1985). Paclobutrazol inhibits the three oxidation steps between ent-kaurene and ent-kaurenoic acid (Hedden and Graebe, 1985).

Paclobutrazol has a wide spectrum of activity (Larson, 1985) on a wide range of species (Goulston, 1985). Besides reducing internode elongation (Larson, 1985), strong growth retardation may increase flower bud formation. The effects of paclobutrazol persist longer than other growth retardants. The degree of activity depends on: plant size, growth stage, environment, season (Goulston, 1985), and application method (Barrett and Bartuska, 1982).

It has been determined that paclobutrazol is absorbed primarily from roots and stems, and not significantly through the leaves (Barrett and Bartuska, 1982; Larson, 1985). Translocation occurs exclusively through the xylem (Goulston, 1985). Aqueous foliar sprays were thought to be ineffective (Larson, 1985; McDaniel, 1983) unless paclobutrazol was mixed with ethanol (McDaniel, 1983). However, Menhenett (1984) found aqueous foliar sprays to be effective. Within pot variations can be attributed to uneven uptake and translocation of paclobutrazol within plants (Menhenett, 1984). Foliar sprays control height in florist's chrysanthemum (Barrett, 1982; Goulston, 1985).

Equal weights of paclobutrazol and ancymidol provide approximately equal height control (Menhenett, 1984).

Paclobutrazol at 30 mg active ingredient (a.i.)/liter foliar spray has approximately the same degree of effectiveness as 5000-7500 mg a.i./liter daminozide (Menhenett, 1984). Both chemicals reduce height and delay anthesis similarly, and have no effect on plant width (Larson and Thorne, 1987) although lateral shoot length may vary more with paclobutrazol due to uneven translocation (Menhenett, 1984).

Concerning LDP, growth retardants applied during LD before FBI is completed will adversely affect flowering. Growth retardants reduce stem length without changing leaf number (Baldev and Lang, 1965), resulting in a compact plant.

Currently, researchers have linked GA synthesis and sensitivity to specific genes which may be manipulated to control morphological parameters such as internode length (Koorneef et al., 1985; Potts et al., 1985). In 1976, Hudson rationalized that chemical growth retardants used as height controllers will eventually be replaced by genetic modification and new cultural techniques (Larson, 1985).

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Growth and Development of *Chrysanthemum carinatum*

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Abstract. Three *Chrysanthemum carinatum* Schousb. varieties were studied for possible potted crop production. Plants of 'Dunnettii Choice Mix' (DC), 'Rainbow Mix' (RM), and 'Single Annual Mix' (SA) were subjected to 8, 11, or 14 weeks SD (9-hr photoperiod) followed by LD (2200 to 0200 HR night interruption), then in a subsequent experiment another set of plants were pinched to 5 or 8 nodes or remained unpinched. Eight weeks of SD provided adequate vegetative growth before flowering. Pinching to 8 nodes resulted in greater flowering uniformity and significantly increased the number of flowers. In a separate experiment, ancymidol [33, 66, or 132 mg active ingredient (a.i.)/liter], daminozide (5000, 7500, or 10,000 mg a.i./liter), paclobutrazol (25, 75, or 125 mg a.i./liter) and a water control were applied as a single application foliar spray after 8 weeks of SD. DC responded with a

significant height reduction only to paclobutrazol at 75 mg a.i./liter; RM was reduced in height by 33 mg a.i./liter ancymidol and 5000 mg a.i./liter daminozide; and SA significantly increased in height with 33 mg a.i./liter ancymidol. However, single foliar sprays provided inadequate height control. Flower diameter was increased for most treatments. In a final experiment, 8 weeks SD and a pinch to 8 nodes was followed by 2 or 3 foliar sprays of the high rates of the above chemicals at 10 day intervals beginning at the start of LD. All treatments gave adequate height reduction, but delayed anthesis. Chemical names used: α-cyclopropyl-α-(4-methoxyphenyl)-5-pyrimidinemethanol (ancymidol); butanedioic acid mono(2,2-dimethylhydrazide) (daminozide); and β-[(4-chlorophenyl)methyl]-α-(1,1-dimethylethyl)-1H-1,2,4-triazole-1-ethanol (paclobutrazol).

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Rainbow daisy differs from traditional flowering potted plants in that it has multicolored flowers and pinnatifid foliage with narrow lobes. Flowers have yellow bands on white rays encircling a purple disk. Crosses with related species resulted in a wide range of colors in a multitude of ringed patterns (3) as well as doubles and semidoubles (6). Consumer demand for unusual flowering potted plants is increasing (1) and the flower and foliage characteristics of rainbow chrysanthemum give it potential to help fill this demand. Traditionally grown as cut flowers (3), rainbow daisy culture at 13°C (13) reduces greenhouse heating costs during winter production (7).

Quantitative longday (LD) plant seedlings develop a tight rosette of foliage under shortdays (SD) (15). LD induce flower bud initiation and development in conjunction with stem elongation. Both responses result from changes in concentration and relative proportion of endogenous gibberellins (9,17,19,20).

According to Staby et al. (18), quality potted crops are not taller or wider than 3 times the height or width of the pot. Growth retardants will be necesasry to reduce the height of rainbow daisy to 30-cm if it is produced in 15-cm pots.

The growth retardants ancymidol, daminozide, and paclobutrazol have reduced stem length on many species,

including chrysanthemums, without reducing flower quality (2,5,10). Besides excessive height, other obstacles to successful flowering potted crop production of rainbow daisy include germination, branching, and photoperiodic response. The objectives of this research were to study growth and development of rainbow daisy and develop production guidelines.

Rainbow daisy varieties Dunnettii Choice Mix (DC), Rainbow Mix (RM), and Single Annual Mix (SA) were used in all experiments. Pot culture was in a 1 part soil : 2 part sphagnum peatmoss : 1 part perlite (by volume) growing medium. Seedlings were grown in 7.5-cm plastic pots for 7 weeks topdressed with Osmocote 14-6-11.6 at 1.5 g/pot, then transplanted to 15-cm pots topdressed with Osmocote 14-6-11.6 at 12 g/pot. Greenhouse temperatures were 24°C days and 15° nights throughout pot culture. For all experiments, irrigation was by Chapin Tube automatic system.

Expt. 1. Germination study. Seeds sown in a commercial peat-lite mix were either covered with fine vermiculite to a depth of 5-mm or left uncovered. Seed trays were exposed to intermittent mist for 6 sec every 6 min between 0800 and 1700 HR. One-half were placed over bottom heat of 28°C from thermostatically controlled electric heat cables. The other half did not receive

supplemental heat; media temperature remained at 18 ± 2^{o}. Ambient temperature was 23^{o}. The experiment was a 2 (media temperature) x 2 (depth) x 3 (variety) factorial design with three 20 seed replications. The number of seedlings which had developed at least one pair of true leaves were counted daily.

Expt. 2. Photoperiod study. Plants were subjected to 8, 11, or 14 weeks SD with 9-hr daylength (black cloth on from 1700 to 0800 HR) beginning at the time of transplanting into 7.5-cm pots. LD following the treatments were created by natural long night interruption with incandescent light between 2200 and 0200 HR. Continuous SD served as the control. Nine single-plant replications were arranged in a completely randomized design in the greenhouse. Data collected at anthesis included: number of days from sowing to anthesis, primary stem length, number of primary nodes, number of secondary stems, and terminal flower diameter.

Expt. 3. Pinch study. Transplants in 7.5-cm pots were grown under 9-hr SD for 4 weeks, then repotted to 15-cm pots at which time the pinching treatments were applied: pinch to 5 nodes, 8 nodes, or no pinch. The plants were maintained under SD 4 additional weeks, then moved to LD. Seven single-plant replications were arranged in a completely randomized design in the greenhouse. Data taken

at anthesis included: number of days from sowing to anthesis, plant height, width, number of secondary stems, number of nodes on the first flowering lateral branch to reach anthesis, flower diameter, number of flower buds showing and not showing color, and total number of flower buds.

Expt. 4. Growth retardant study. Plants were maintained under 9-hr SD for 7 weeks then placed under natural LD and growth retardants were applied. Single foliar sprays to the drip point were made of the following chemicals and rates: ancymidol at 33, 66, or 132 mg active ingredient (a.i.)/liter; daminozide at 5000, 7500, or 10,000 mg a.i./liter; paclobutrazol at 25, 75, or 125 mg a.i./liter; or a water control. Ten single-plant replications were arranged in a completely randomized design in the greenhouse. Data collected at anthesis included: number of days from sowing to anthesis, plant height, width, number of nodes on tallest stem, and flower diameter.

Expt. 5. Growth retardant with pinching study. Plants were maintained under 9-hr SD for 8 weeks, then pinched leaving 8 nodes and placed under LD created by natural longnight interruption by incandescent lights between 1000 and 0200 HR. Treatments, begun one week after the start of LD, were 2 or 3 foliar spray applications to

the drip point of either ancymidol at 132 mg a.i./liter, daminozide at 10,000 mg a.i./liter, paclobutrazol at 125 mg a.i./liter, or a water control. The second and third applications were made at 10 day intervals. Ten single-plant replications were arranged in a randomized block design in the greenhouse. Data taken at anthesis included: number of days from sowing to anthesis, plant height, width, total number of secondary stems, number of secondary stems longer than 10-mm, total number of flower buds, number of flower buds showing color, length of the first stem to reach anthesis, number of nodes on the first flowering lateral branch reaching anthesis, and flower diameter.

Data from all experiments were analyzed using analysis of variance and L.S.D. to compare significant effects (p = 0.05) means using either analysis of variance for complete cells or analysis of variance using the general linear model of the Statistical Analysis System (16) for data sets with incomplete cells .

Expt. 1. After 21 days, covered seeds had significantly (5% level, t-test) greater germination (64%) and more rapid seedling development (36.5%) than uncovered seed (49% and 14% respectively). Uncovered seed were susceptible to dessication over night since intermittent mist was not used between 1700 and 0800 HR, and the

seedling radicles were not able to penetrate into the medium. There was increased susceptability to stem rot and leaf rot organisms due to soil contact by the stems and leaves evidently because the plants were not anchored by the roots.

Bottom heat significantly improved germination (61%) compared to no bottom heat temperature (52%) (P>F=0.0362). However, adding heat resulted in significantly fewer seedlings developing true leaves (18%) than unheated seedlings (32%) (P>F=0.0024).

Expt. 2. Decreasing exposure to SD, from continuous SD (control) to 8 weeks SD, decreased the number of laterals and days to anthesis whereas stemlength increased (Table 1). The number of lateral branches was uniformly reduced for all treatments compared to the control. This was probably due to LD photoperiods terminating vegetative growth sooner, leaving fewer lateral buds capable of developing into branches by anthesis. Stem length was greatest at 11 weeks SD while there was no increase in the number of primary nodes after 11 weeks SD (Fig. 1).

Some significant (5% level using an L.S.D.) varietal differences were observed. The number of primary nodes formed on SA (28.8) and DC (29.3) were significantly different from RM (32.6). SA flowered significantly sooner and had significantly larger flowers (122.6 days, 6.7 cm)

than DC (127.4 days, 6.2 cm) and RM (129.6 days, 5.9 cm).

Expt. 3. Pinching significantly increased the number of days to anthesis, plant width, number of flower buds showing color, buds not showing color, and total number of buds; and decreased lateral branching (Table 2). Rainbow daisy has a determinate flowering pattern. Pinching removed the terminal flower bud leaving the less developed secondary buds to flower first which took longer. Pinching to either 5 or 8 nodes reduced flower diameter on DC whereas flower diameter was unaffected on SA and RM. Plant width of DC was increased by pinching to 8 nodes and on RM by pinching to 5 nodes. The decrease in flower diameter may be due to plant hormones or insufficient nutrient uptake to support the additional flower buds approaching anthesis. Plant width of SA was uneffected by pinching (Table 3).

Pinch treatments caused no significant change in plant height or number of primary nodes. These parameters also did not differ significantly among the varieties. However, RM flowered significantly (P>F=0.0174) sooner (113.9 days) than SA (119.7) and DC (120.7).

Expt. 4. Growth retardant treatments did not significantly affect the number of days to anthesis, plant width, or primary node number. A single spray application of ancymidol or daminozide did not reduce plant height of

DC. However, paclobutrazol at 75 mg a.i./liter rate significantly reduce height. RM was significantly reduced in height by 33 mg a.i./liter ancymidol and 5000 mg a.i./liter daminozide. All other treatments were not significantly different from the control. The height of 5A was increased by all treatments, but only 33 mg a.i./liter ancymidol exhibited a significant increase (Table 4). Growth stimulation by low rates of growth retardants has been known to occur with ancymidol on chrysanthemums (10), and with ancymidol, daminozide, and paclobutrazol on Epipremnum, Pelargonium, and Schefflera (7). Also there may have been a growth surge of plants once the growth retardant effect was overcome.

There was no growth retardant-variety interaction on flower size. Flower diameter was significantly increased to varying degrees by the 3 chemicals (Table 5).

Expt. 5. Flower diameter, number of flower buds showing color and not showing color, plant diameter, total number of laterals, and number of laterals longer than 10-mm were not affected by growth retardant treatments and were not different among varieties. The significant differences among varieties is consistant for days to anthesis, length of first flowering lateral, and plant height (Table 6). These plant parameters were also significantly affected by the growth retardant treatments

(Table 6). Ancymidol and daminozide applications yielded the greatest reduction in the length of the first flwoering lateral branch. All growth retardants significantly reduced plant height. However, there was no growth retardant treatment - variety interaction for any plant parameter measured.

Although a commercially acceptable potted crop of rainbow daisy was not realized by this research, problems concerning germination, branching, photoperiod, and height have been overcome. To produce a commercially acceptable crop, further work is necessary.

Paramount is the problem of horizontal growth of lateral branching exhibited by pinched plants treated with growth retardants. By manipulating the timing of the pinch in conjunction with the strength and frequency of growth retardant sprays, vertical growth of lateral branches may resume as in untreated pinched plants.

The terminal flower bud of lateral branches (morphologically described as secondary buds) blooms first, then declines as tertiary buds bloom sporadically but in profusion. A more attractive plant would have an initial profusion of flowers distributed uniformly across the plant. It may be possible to facilitate this response in rainbow daisy by centerbudding the lateral branches (removing the secondary flower buds), thereby encouraging

the uniform development of the greater number of tertiary buds.

Seasonal differences in crop performance is also a problem. Summer heat and humidity cause weak, spindly growth which is more susceptible to insects and diseases. Zinnia exhibited predictable seasonal variations in days to anthesis which was attributed to mean daily temperature and photosynthetic photon flux (4). Seasonal parameters alter the influence of growth retardants (14). Summer crops generally require higher concentrations of growth retardants to obtain satisfactory height control (12).

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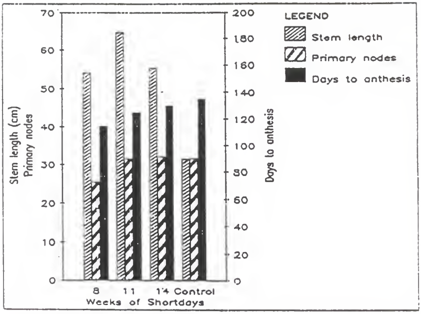

Figure 1. Stem length, number of primary nodes, and days to anthesis for Chrysanthemum carinatum plants grown under SD for different lengths of time followed by LD (contol is continuous SD).

Table 1. Plant parameters significantly affected by photoperiod treatment of <u>Chrysanthemum carinatum</u>.

Treatment	Days to anthesis	Stem length (cm)	Primary nodes (no.)	Lateral branches (no.)
Control	135 a[z]	31.6 c	31.8 a	18.0 a
14 weeks SD	130 b	55.3 b	32.2 a	14.6 b
11 weeks SD	125 c	64.8 a	31.6 a	14.8 b
8 weeks SD	115 d	54.2 b	25.5 b	14.7 b

[z]Mean separation within columns by L.S.D., P=0.05.

Table 2. Plant parameters significantly changed by pinch treatments of <u>Chrysanthemum carinatum</u>.

	Days to anthesis	Plant width (cm)	Lateral branches (no.)	Flower buds		
				Color	No color	Total
Control	111 b[z]	38.2 b	13.4 a	1.0 c	2.9 c	4.0 c
5 nodes	123 a	44.0 a	5.4 c	2.3 b	6.6 b	9.0 b
8 nodes	121 a	42.5 a	8.2 b	2.7 a	9.9 a	12.6 a

[z]Mean separation within each column by L.S.D., P=0.05.

Table 3. Interaction of variety and pinch treatment on plant width and flower diameter of C. carinatum var. Dunnetti Choice Mix (DC), Rainbow Mix (RM), and Single Annual Mix (SA).

	Variety		
	DC	RM	SA
Plant width (cm)			
Control	34.7 c[z]	38.7 bc	41.1 bc
5 Nodes	37.7 c	48.8 a	45.5 ab
8 Nodes	43.0 b	44.0 ab	40.5 bc
Flower diameter (cm)			
Control	5.6 a[z]	4.8 bc	5.3 ab
5 Nodes	4.7 c	4.9 bc	5.2 abc
8 Nodes	5.0 bc	5.0 bc	4.9 bc

[z]Mean separation across all cultivars by L.S.D., P=0.05.

Table 4. Plant height response of <u>Chrysanthemum carinatum</u> var. Dunnetti Choice Mix (DC), Rainbow Mix (RM), and Single Annual Mix (SA) to single foliar applications of ancymidol, daminozide, or paclobutrazol..

Chemical (mg a.i./liter)	Plant height (cm)		
	DC	RM	SA
Control	59.6 b[z]	70.7 a	46.9 b
Ancymidol			
33	61.0 b	50.6 b	65.4 a
66	66.4 b	66.1 a	58.0 ab
132	64.8 b	62.3 ab	51.8 b
Daminozide			
5000	63.0 b	49.7 b	60.3 b
7500	55.3 b	59.4 ab	61.2 b
10,000	62.0 b	64.8 a	60.2 b
Paclobutrzol			
25	67.7 ab	59.7 a	57.6 b
75	48.8 c	64.3 a	57.7 b
125	79.1 a	60.3 a	57.8 b

[z]Means within each variety separated by L.S.D., P=0.05.

Table 5. Flower diameter changes induced by a single application of growth retardants on *Chrysanthemum carinatum*.

Chemical (mg a.i./liter)	Flower diameter (cm)
Control	5.73 c[z]
Ancymidol	
33	5.93 bc
66	6.26 ab
132	6.16 bc
Daminozide	
5000	6.27 ab
7500	6.14 bc
10,000	6.73 a
Paclobutrazol	
25	6.03 bc
75	6.34 ab
125	6.32 ab

[z]Mean separation by LSD, $P=0.05$.

Table 6. Varietal and growth retardant treatment differences for different plant parameters on <u>Chrysanthemum carinatum</u> var. Dunnetti Choice Mix (DC), Rainbow Mix (RM), and Single Annual Mix (SA).

Main effect	Days to anthesis	Length of first flowering lateral (cm)	Plant height (cm)
Variety			
DC	129 b[z]	41.7 b	30.2 a
RM	131 a	43.0 a	30.1 a
SA	127 c	39.1 c	26.8 b
Growth retardants			
Control	126 d	52.9 a	44.2 a
Ancymidol[y]			
2 applications	131 ab	39.9 bc	25.5 bc
3 applications	133 a	36.1 c	24.2 c
Daminozide			
2 applications	129 bc	39.9 bc	25.5 bc
3 applications	129 bc	37.5 c	25.4 bc
Paclobutrazol			
2 applications	127 cd	42.0 b	29.5 b
3 applications	129 bc	42.6 b	27.2 bc

[z]Mean separation by LSD, P=0.05.

[y]Rates used were: ancymidol 132 mg a.i./liter; daminozide 10,000 mg a.i./liter; and paclobutrazol 125 mg a.i./liter applied 2 or 3 times.

APPENDIX A

Analysis of Variance Tables

Experiment #1: Germination study.

Dependent variable: Expanded cotyledons

Source	df	Sum of squares	Mean square	F-value
Model	11	403.3333	36.6667	6.35
Error	24	138.6667	5.7778	PR>F
Corrected				0.0001
total	35	542.0000		

R-square	C.V.	Root M.S.E.	Exp. Cot. mean
0.7441	21.2091	2.4037	11.3333

Source	df	Anova SS	F-value	PR>F
Variety	2	193.1667	16.72	0.0001
Condition	1	81.0000	14.02	0.0010
Heat	1	28.4444	4.92	0.0362
Var*Cond	2	15.1667	1.31	0.2878
Var*Heat	2	14.3889	1.25	0.3058
Cond*Heat	1	32.1111	5.56	0.0269
Var*Heat* Cond	2	39.0555	3.38	0.0509

Experiment #1: Germination study.

Dependent variable: First expanded true-leaves

Source	df	Sum of squares	Mean square	F-value
Model	11	481.6389	43.7853	6.68
Error	24	157.3333	6.5555	PR>F
Corrected total	35	638.9722		0.0001

R-square	C.V.	Root M.S.E.	True leaves
0.7538	50.9247	2.5604	5.0278

Source	df	Anova SS	F-value	PR>F
Variety	2	90.0555	6.87	0.0044
Condition	1	182.2500	27.80	0.0001
Heat	1	72.2500	11.02	0.0029
Var*Cond	2	60.5000	4.61	0.0202
Var*Heat	2	20.1667	1.54	0.2352
Cond*Heat	1	34.0278	5.19	0.0319
Var*Heat* Cond	2	22.3889	1.71	0.2026

Experiment #2: <u>Photoperiod study.</u>

Dependent variable: <u>Days to anthesis</u>

Source	df	Sum of squares	Mean square	F-value
Model	23	8656.1019	376.3523	7.75
Error	84	4076.6667	48.5317	PR>F
Corrected				0.0001
total	107	12732.7685		

R-square	C.V.	Root M.S.E.	Days to anthesis mean
0.6798	5.5269	6.9665	126.0463

Source	df	Type III SS	F-value	PR>F
Variety	2	794.7516	8.19	0.0006
Shortday	3	6421.3167	44.10	0.0001
Size	1	640.5710	13.20	0.0005
Var*Shrtday	6	157.7280	0.54	0.7751
Var*Size	2	103.2679	1.06	0.3497
Shrtday*Size	3	330.6393	2.27	0.0849
Var*Size* Shrtday	6	207.8273	0.71	0.6395

<u>Experiment #2: Photoperiod study.</u>

Dependent variable: <u>Stem length (cm)</u>

Source	df	Sum of squares	Mean square	F-value
Model	23	20020.7176	870.4660	7.21
Error	84	10145.9985	120.7857	PR>F
Corrected				0.0001
total	107	30166.7161		

R-square	C.V.	Root M.S.E.	Stem length mean
0.6637	21.2680	10.9902	51.67523

Source	df	Type III SS	F-value	PR>F
Variety	2	150.1792	0.62	0.5395
Shortday	3	14213.4364	39.22	0.0001
Size	1	152.8854	1.27	0.2638
Var*Shrtday	6	1662.8005	2.29	0.0423
Var*Size	2	387.3372	1.60	0.2073
Shrtday*Size	3	224.5619	0.62	0.6081
Var*Size* Shrtday	6	87.7441	0.12	0.9936

Experiment #2: Photoperiod study.

Dependent variable: Flower diameter (cm)

Source	df	Sum of squares	Mean square	F-value
Model	23	21.1369	0.9190	1.52
Error	84	50.6512	0.6030	PR>F
Corrected				0.0850
total	107	71.7881		

R-square	C.V.	Root M.S.E.	Flower diameter mean
0.2944	12.3974	0.7765	6.2636

Source	df	Type III SS	F-value	PR>F
Variety	2	12.6917	10.52	0.0001
Shortday	3	0.8557	0.47	0.7057
Size	1	0.0766	0.13	0.7224
Var*Shrtday	6	3.2597	0.90	0.4983
Var*Size	2	0.1193	0.10	0.9059
Shrtday*Size	3	0.9374	0.52	0.6749
Var*Size*				
Shrtday	6	2.8033	0.77	0.5919

Experiment #2: Photoperiod study.

Dependent variable: Number of primary nodes

Source	df	Sum of squares	Mean square	F-value
Model	23	1475.7074	64.1612	2.29
Error	84	2354.6167	28.0311	PR>F
Corrected				0.0033
total	107	3830.3241		

R-square	C.V.	Root M.S.E.	No. primary nodes mean
0.3852	17.4489	5.2944	30.3426

Source	df	Type III SS	F-value	PR>F
Variety	2	312.5330	5.57	0.0053
Shortday	3	816.6071	9.71	0.0001
Size	1	88.1510	3.14	0.0798
Var*Shrtday	6	55.5319	0.33	0.9193
Var*Size	2	29.1803	0.52	0.5961
Shrtday*Size	3	7.9141	0.09	0.9581
Var*Size*				
Shrtday	6	96.3113	0.57	0.7510

Experiment #2: Photoperiod study.

Dependent variable: Number of lateral branches

Source	df	Sum of squares	Mean square	F-value
Model	23	497.8241	21.6445	1.35
Error	84	1350.5000	16.0777	PR>F
Corrected total	107	1848.3241		0.1642

R-square	C.V.	Root M.S.E.	Lateral branches mean
0.2693	26.1342	4.0097	15.3459

Source	df	Type III SS	F-value	PR>F
Variety	2	33.8267	1.05	0.3538
Shortday	3	198.7131	4.12	0.0090
Size	1	6.7835	0.42	0.5177
Var*Shrtday	6	91.0364	0.94	0.4684
Var*Size	2	17.7519	0.55	0.5778
Shrtday*Size	3	103.9069	2.15	0.0980
Var*Size* Shrtday	6	113.7355	1.18	0.3254

Experiment #3: Pinch study.

Dependent variable: Number of lateral branches

Source	df	Sum of squares	Mean square	F-value
Model	8	2066.1759	258.2720	28.39
Error	171	1555.4685	9.0963	PR>F
Corrected total	179	3621.6444		0.0001

R-square	C.V.	Root M.S.E.	Lateral branches mean
0.5705	33.3465	3.0160	9.0444

Source	df	Type III SS	F-value	PR>F
Variety	2	9.7349	0.54	0.5866
Pinch	2	2007.5323	110.35	0.0001
Var*Pinch	4	38.4726	1.06	0.3793

Experiment #3: Pinch study.

Dependent variable: Total number of flower buds

Source	df	Sum of squares	Mean square	F-value
Model	8	2406.0448	300.7556	15.47
Error	171	3324.9051	19.4439	PR>F
Corrected				0.0001
total	179	5730.9500		

R-square	C.V.	Root M.S.E.	Total flower buds mean
0.4198	51.9787	4.4095	8.4833

Source	df	Type III SS	F-value	PR>F
Variety	2	10.5029	0.27	0.7636
Pinch	2	2235.2272	57.48	0.0001
Var*Pinch	4	138.4623	1.78	0.1350

Experiment #3: Pinch study.

Dependent variable: No. buds not showing color

Source	df	Sum of squares	Mean square	F-value
Model	8	1599.7852	199.9731	12.38
Error	171	2762.7648	16.1565	PR>F
Corrected				0.0001
total	179	4362.5500		

R-square	C.V.	Root M.S.E.	Buds w/ no color mean
0.3667	62.3181	4.0195	6.4500

Source	df	Type III SS	F-value	PR>F
Variety	2	20.7081	0.64	0.5281
Pinch	2	1429.2142	44.23	0.0001
Var*Pinch	4	130.2761	2.02	0.0944

Experiment #3: Pinch study.

Dependent variable: No. buds showing color

Source	df	Sum of squares	Mean square	F-value
Model	8	101.4702	12.6838	10.21
Error	171	212.3298	1.2417	PR>F
Corrected total	179	313.8000		0.0001

R-square	C.V.	Root M.S.E.	Buds w/ color mean
0.3233	54.8023	1.1143	2.0333

Source	df	Type III SS	F-value	PR>F
Variety	2	2.1942	0.88	0.4152
Pinch	2	94.4788	38.04	0.0001
Var*Pinch	4	5.3589	1.08	0.3685

Experiment #3: Pinch study.

Dependent variable: No. of internodes

Source	df	Sum of squares	Mean square	F-value
Model	8	536.1749	67.0219	0.63
Error	171	18246.1529	106.7026	PR>F
Corrected total	179	18782.3278		0.7534

R-square	C.V.	Root M.S.E.	No. of internodes mean
0.0285	25.8638	10.3297	39.9389

Source	df	Type III SS	F-value	PR>F
Variety	2	199.5325	0.93	0.3946
Pinch	2	275.0985	1.29	0.2782
Var*Pinch	4	49.8293	0.12	0.9764

Experiment #3: Pinch study.

Dependent variable: Flower diameter (cm)

Source	df	Sum of squares	Mean square	F-value
Model	8	12.4148	1.5518	2.19
Error	171	121.0121	0.7077	PR>F
Corrected				0.0302
total	179	133.4269		

R-square	C.V.	Root M.S.E.	Flower diameter mean
0.0930	16.6253	0.8412	5.0600

Source	df	Type III SS	F-value	PR>F
Variety	2	1.7132	1.21	0.3006
Pinch	2	2.6823	1.90	0.1534
Var*Pinch	4	7.8942	2.78	0.0286

Experiment #3: Pinch study.

Dependent variable: Plant width (cm)

Source	df	Sum of squares	Mean square	F-value
Model	8	3000.3010	375.0376	5.61
Error	171	11436.5287	66.8803	PR>F
Corrected				0.0001
total	179	14436.8297		

R-square	C.V.	Root M.S.E.	Plant width mean
0.2078	19.6836	8.1780	41.5475

Source	df	Type III SS	F-value	PR>F
Variety	2	930.7351	6.96	0.0012
Pinch	2	1102.6823	8.24	0.0004
Var*Pinch	4	901.3334	3.37	0.0110

Experiment #3: Pinch study.

Dependent variable: Plant height (cm)

Source	df	Sum of squares	Mean square	F-value
Model	8	884.2231	110.5279	0.55
Error	171	34057.4156	199.1661	PR>F
Corrected total	179	34941.6388		0.8135

R-square	C.V.	Root M.S.E.	Plant height mean
0.0253	34.5237	14.1126	40.8781

Source	df	Type III SS	F-value	PR>F
Variety	2	19.0189	0.05	0.9534
Pinch	2	698.4713	1.75	0.1763
Var*Pinch	4	154.5982	0.19	0.9412

Experiment #3: Pinch study.

Dependent variable: Days to anthesis

Source	df	Sum of squares	Mean square	F-value
Model	8	7547.0568	943.3821	4.89
Error	171	32972.7432	192.8231	PR>F
Corrected total	179	40519.8000		0.0001

R-square	C.V.	Root M.S.E.	Days to anthesis mean
0.1863	11.7645	13.8861	118.0333

Source	df	Type III SS	F-value	PR>F
Variety	2	1559.0597	4.15	0.0174
Pinch	2	4976.2709	12.90	0.0001
Var*Pinch	4	1042.2782	1.35	0.2530

Experiment #4: Growth retardant study.

Dependent variable: Days to anthesis

Source	df	Sum of squares	Mean square	F-value
Model	29	7287.8812	251.3062	1.32
Error	242	46207.3982	190.9397	PR>F
Corrected				0.1367
total	271	53495.2794		

R-square	C.V.	Root M.S.E.	Days to anthesis mean
0.1362	10.4922	13.8181	131.6985

Source	df	Type III SS	F-value	PR>F
Variety	2	530.8503	1.39	0.2510
Chemical	9	1592.2231	0.93	0.5033
Var*Chem	18	5294.5231	1.54	0.0770

Experiment #4: Growth retardant study.

Dependent variable: Plant height (cm)

Source	df	Sum of squares	Mean square	F-value
Model	29	11870.8474	489.3395	1.80
Error	242	54990.7243	227.2343	PR>F
Corrected				0.0094
total	271	66861.5717		

R-square	C.V.	Root M.S.E.	Plant height mean
0.1775	24.9691	15.0743	60.3717

Source	df	Type III SS	F-value	PR>F
Variety	2	1234.9853	2.72	0.0681
Chemical	9	1876.8775	0.92	0.5110
Var*Chem	18	8848.5455	2.16	0.0048

Experiment #4: Growth retardant study.

Dependent variable: Plant width (cm)

Source	df	Sum of squares	Mean square	F-value
Model	29	2428.0095	83.7244	1.41
Error	242	14342.6638	59.2672	PR>F
Corrected				0.0853
total	271	16770.6733		

R-square	C.V.	Root M.S.E.	Plant width mean
0.1448	21.7983	7.6985	35.3171

Source	df	Type III SS	F-value	PR>F
Variety	2	79.0565	0.67	0.5142
Chemical	9	607.4566	1.14	0.3357
Var*Chem	18	1720.1575	1.61	0.0576

Experiment #4: Growth retardant study.

Dependent variable: Flower diameter (cm)

Source	df	Sum of squares	Mean square	F-value
Model	29	44.9361	1.5495	1.70
Error	242	220.3571	0.9106	PR>F
Corrected				0.0172
total	271	265.2931		

R-square	C.V.	Root M.S.E.	Flower diameter mean
0.1694	15.3932	0.9542	6.1991

Source	df	Type III SS	F-value	PR>F
Variety	2	12.6421	6.94	0.0012
Chemical	9	17.2145	2.10	0.0301
Var*Chem	18	14.8908	0.91	0.5687

Experiment #4: Growth retardant study.

Dependent variable: No. of internodes

Source	df	Sum of squares	Mean square	F-value
Model	29	5426.0231	187.1042	2.04
Error	242	22155.3864	91.9311	PR>F
Corrected total	271	27581.4096		0.0021

R-square	C.V.	Root M.S.E.	Internodes mean
0.1967	18.7121	9.5881	51.2398

Source	df	Type III SS	F-value	PR>F
Variety	2	654.4956	3.56	0.0300
Chemical	9	859.8905	1.04	0.4094
Var*Chem	18	3718.6324	2.25	0.0032

Experiment #5: Growth retardants with pinching.

Dependent variable: Days to anthesis

Source	df	Sum of squares	Mean square	F-value
Model	20	2070.4596	103.5230	3.06
Error	188	6353.5212	33.7953	PR>F
Corrected total	208	8423.9809		0.0001

R-square	C.V.	Root M.S.E.	Days to anthesis mean
0.2458	4.5068	5.8134	128.9904

Source	df	Type III SS	F-value	PR>F
Variety	2	402.3968	5.95	0.0031
Chemical	6	1006.5513	4.96	0.0001
Var*Chem	12	694.3540	1.71	0.0669

Experiment #5: Growth retardants with pinching.

Dependent variable: Flower diameter (mm)

Source	df	Sum of squares	Mean square	F-value
Model	20	1380.7584	69.0379	1.26
Error	188	10340.7535	55.0040	PR>F
Corrected				0.2144
total	208	11721.5120		

R-square	C.V.	Root M.S.E.	Flower diameter mean
0.1178	12.8156	7.4165	57.8708

Source	df	Type III SS	F-value	PR>F
Variety	2	408.0908	3.71	0.0263
Chemical	6	610.8669	1.85	0.0914
Var*Chem	12	370.9606	0.56	0.8705

Experiment #5: Growth retardants with pinching.

Dependent variable: Buds with color

Source	df	Sum of squares	Mean square	F-value
Model	20	132.7796	6.6389	1.22
Error	188	1023.4596	5.4439	PR>F
Corrected				0.2420
total	208	1156.2392		

R-square	C.V.	Root M.S.E.	Buds with color mean
0.1148	53.0048	2.3332	4.40198

Source	df	Type III SS	F-value	PR>F
Variety	2	50.0026	4.59	0.0113
Chemical	6	29.9739	0.92	0.4834
Var*Chem	12	53.9538	0.83	0.6236

Experiment #5: Growth retardants with pinching.

Dependent variable: Buds, no color

Source	df	Sum of squares	Mean square	F-value
Model	20	1505.8895	75.2945	1.54
Error	188	9213.3545	49.0072	PR>F
Corrected				0.0733
total	208	10719.2440		

R-square	C.V.	Root M.S.E.	Buds, no color mean
0.1408	35.2047	7.0005	19.8852

Source	df	Type III SS	F-value	PR>F
Variety	2	218.2100	2.23	0.1108
Chemical	6	748.8216	2.55	0.0215
Var*Chem	12	528.6649	0.90	0.5491

Experiment #5: Growth retardants with pinching.

Dependent variable: Total no. of lateral branches

Source	df	Sum of squares	Mean square	F-value
Model	20	52.3095	2.6155	1.47
Error	188	333.3747	1.7733	PR>F
Corrected				0.0942
total	208	385.6842		

R-square	C.V.	Root M.S.E.	Lateral branches mean
0.1357	14.9711	1.3316	8.8947

Source	df	Type III SS	F-value	PR>F
Variety	2	3.7168	1.05	0.3527
Chemical	6	13.3711	1.26	0.2795
Var*Chem	12	34.6443	1.63	0.0867

Experiment #5: Growth retardants with pinching.

Dependent variable: Total no. of laterals > 10 mm

Source	df	Sum of squares	Mean square	F-value
Model	20	86.7194	4.3350	1.40
Error	188	582.6586	3.0992	PR>F
Corrected				0.1268
total	208	669.3780		

R-square	C.V.	Root M.S.E.	Laterals >10 mm mean
0.1295	23.6768	1.7605	7.4354

Source	df	Type III SS	F-value	PR>F
Variety	2	5.8322	0.94	0.3921
Chemical	6	49.3177	2.65	0.0171
Var*Chem	12	31.3494	0.84	0.6062

Experiment #5: Growth retardants with pinching.

Dependent variable: Plant width (cm)

Source	df	Sum of squares	Mean square	F-value
Model	20	3406.1073	170.3053	1.63
Error	188	19653.1767	104.5382	PR>F
Corrected				0.0495
total	208	23059.2840		

R-square	C.V.	Root M.S.E.	Plant width mean
0.1477	19.2066	10.2244	53.2337

Source	df	Type III SS	F-value	PR>F
Variety	2	368.8104	1.76	0.1742
Chemical	6	1319.8015	2.10	0.0546
Var*Chem	12	1706.0348	1.36	0.1885

Experiment #5: Growth retardants with pinching.

Dependent variable: Length of first flowering lateral (cm)

Source	df	Sum of squares	Mean square	F-value
Model	20	7106.4603	355.3230	5.81
Error	188	11503.0525	61.1864	PR>F
Corrected				0.0001
total	208	18609.5129		

R-square	C.V.	Root M.S.E.	1st flw. lateral mean
0.3819	18.9821	7.8221	41.2081

Source	df	Type III SS	F-value	PR>F
Variety	2	559.2596	4.57	0.0115
Chemical	6	5721.8305	15.59	0.0001
Var*Chem	12	783.8910	1.07	0.3897

Experiment #5: Growth retardants with pinching.

Dependent variable: No. of nodes

Source	df	Sum of squares	Mean square	F-value
Model	20	873.0217	43.6511	1.82
Error	188	4497.1697	23.9211	PR>F
Corrected				0.0206
total	208	5370.1914		

R-square	C.V.	Root M.S.E.	No. of nodes mean
0.1626	17.5065	4.8909	27.9378

Source	df	Type III SS	F-value	PR>F
Variety	2	351.6283	7.35	0.0008
Chemical	6	232.9555	1.62	0.1428
Var*Chem	12	296.2772	1.03	0.4211

Experiment #5: Growth retardants with pinching.

Dependent variable: Plant height (cm)

Source	df	Sum of squares	Mean square	F-value
Model	20	10126.1031	506.3051	6.91
Error	188	13702.6469	73.2762	PR>F
Corrected total	208	23828.7500		0.0001

R-square	C.V.	Root M.S.E.	Plant height mean
0.4249	29.5122	8.5601	29.0054

Source	df	Type III SS	F-value	PR>F
Variety	2	525.0970	3.58	0.0297
Chemical	6	8553.9023	19.46	0.0001
Var*Chem	12	990.1605	1.13	0.3412

GROWTH AND DEVELOPMENT OF

CHRYSANTHEMUM CARINATUM SCHOUSB. (ASTERACEAE)

by

ROBERT M. BALEK

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AN ABSTRACT OF A THESIS

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ABSTRACT

Chrysanthemum carinatum Schousb., rainbow daisy, has potential as a potted flowering plant if the problems of seed germination, photoperiodic response, lateral branch growth, and excessive height can be overcome. Varieties used in each experiment were 'Dunnettii Choice Mix', 'Rainbow Mix', and 'Single Annual Mix' (DC, RM, and SA respectively). Techniques used to improve germination were bottom heat, intermittent mist, and seed cover. Covered seed had greater germination rate and more developed seedlings by day 21. Heated seed germinated faster but fewer seedlings developed by day 21.

Plant response to photoperiod involved exposure to 8, 11, and 14 weeks of 9-hr shortdays (SD) or continuous SD. All plants flowered sooner after 8 weeks SD and had fewer nodes and lateral branches.

Pinching plants to 5 or 8 nodes induced later flowering, more flower buds, and fewer lateral branches. Plant width increased for DC when pinched to 8 nodes and for RM when pinched to 5 nodes.

Growth retardants were used as an attempt to control plant height. Foliar sprays of ancymidol (33, 66, or 132 mg a.i./liter), daminozide (5000, 7500, or 10,000 mg a.i./liter), and paclobutrazol (25, 75, or 125 mg a.i./liter) were used. A single foliar application of any

of these growth retardants was inadequate for controlling height through anthesis.

When combining 8 weeks of SD with a pinch to 8 nodes and either 2 or 3 foliar sprays of ancymidol, daminozide, or paclobutrazol at 132, 10,000, and 125 mg a.i./liter respectively, plant height was reduced by all chemical treatments without affecting node number. Flower parameters were generally unaffected. Lateral number was unaffected except for DC which exhibited a reduction in lateral branching due to daminozide treatments.